

Bridging Policy and Practice with Ethnomathematics

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Abstract

In an effort to bridge policy and practice in diverse populations, research was conducted at U.S. higher educational institutions (Harvard, UCLA, University of Hawai'i) in the field of ethnomathematics. Ethnomathematics addresses first, how cultural values affect teaching, learning, and curriculum; and second, how mathematics education affects schooling process dynamics. A macroperspective provides a foundation for exploring the policy framework that will be bridged by ethnomathematics to explore practices at the school level (equity and quality education, building successful partnerships, mentoring in diverse populations). This has been accomplished primarily through the Hōkūle'a, a voyaging canoe internationally renowned for rekindling the Pacific tradition of celestial navigation to locations such as Tahiti, Rarotonga, Micronesia, Japan, and the U.S., and is preparing for a worldwide voyage in 2013 of which the author will be participating in. It is a vehicle to explore real-world mathematics applications in global communities, and represents resourcefulness, inventiveness, wisdom grounded in the past, and hope for the future.

He lawai‘a no ke kai papa‘u, he pōkole ke aho;

he lawai‘a no ke kai hohonu he loa ke aho.

A fisherman of the shallow sea uses only a short line;

a fisherman of the deep sea has a long line.

This ‘Ōlelo No‘eau (proverb) was the guiding saying of the research study. One whose knowledge is shallow does not have much, but one whose knowledge is deep has the ability to deepen perspectives through partnerships with culture and traditions that permeate pedagogy, practices, and values.

In an effort to bridge policy and practice in diverse populations, research focuses on a study conducted at U.S. higher educational institutions (Harvard University, UCLA, and the University of Hawai‘i) in the field of ethnomathematics. Ethnomathematics refers to a broad cluster of ideas ranging from distinct numerical and mathematical systems to multicultural education, including race/ethnicity, socioeconomic class, and special needs (D’Ambrosio, 2001). It allows us to address how cultural values can affect teaching, learning, and curriculum; and how mathematics education can then affect political and social dynamics in the schooling process.

A macroperspective of mathematics at the national, state, and local levels provides a foundation for exploring the policy framework. This will then be bridged by ethnomathematics in order to view practices at the grassroots, school level. As examples of ethnomathematics, the University of Hawai‘i – West O‘ahu has implemented the following: (1) equity and quality education, (2) building successful partnerships and practices, and (3) mentoring in diverse populations. This has been made possible by a National Science Foundation grant and has been

accomplished primarily through the Hōkūle‘a, “star of gladness,” a double-hulled Hawaiian voyaging canoe that is an integral part of research.

Policy Framework

A number of studies show Hawai‘i’s reference to national and international populations. The Programme for International Student Assessment (PISA) is a triennial survey of the knowledge and skills of 15 year olds. It is the product of collaboration between participating countries and economies through the Organisation for Economic Cooperation and Development (OECD). More than 400,000 students in 57 countries making up close to 90% of the world economy took part in PISA 2006. The focus was on science but the assessment also included reading and mathematics and collected data on student, community, and institutional factors that could help to explain differences in performance such as culture and family background (PISA, 2006).

The U.S. currently ranks 25th out of 30 OECD countries in mathematics. In the 2003 PISA study, although the U.S.’s ranking remained fairly static, 24th out of 29 OECD countries, the mean score dropped from 483 in 2003 to 474 in 2006. By contrast, top ranking countries Finland and Korea increased (Finland 544 to 548; Korea 542 to 547). Mexico, ranked last both times, improved its score from 385 in 2003 to 411 in 2006. Although the U.S. relative ranking has stayed constant, the overall mean scores of the countries at the top and bottom increased (OECD, 2009).

We know the U.S. has challenges to overcome, but some states are performing extremely well such as Massachusetts. Near the other end of the spectrum is Hawai‘i. The National Assessment of Educational Progress (NAEP) mathematics assessment is administered periodically to 4th and 8th graders. NAEP results serve as a common metric for all states and

selected urban districts. In a state comparison of NAEP 8th grade mathematics average scaled scores from the 2007 assessment, Hawai‘i’s average scale score of 269 is significantly lower than the national average of 280. In fact, Hawai‘i is ranked 47 out of 50 states (NCES, 2007). According to the University of Hawai‘i Vice President of Community Colleges John Morton, “This [mathematics] is not a new problem, what is new is that we’re working together” (Morton, J., Personal Conversation, October 10, 2011).

Hawai‘i is the only statewide school district in the country, and it has functioned this way since before it became a state. Its first public school law in 1840 included a centralized structure. According to the University of Hawai‘i Institutional Research Office, 77.0% of the 7,754 public, parochial, and independent school students go on to attend one of the University of Hawai‘i 10 campuses (UH IRO, 2012). In spite of these illuminating statistics, the first statewide Mathematics Summit “Defining the Mathematics Crisis”, designed to facilitate discussion and action on raising mathematics achievement levels of Hawai‘i students to ensure college and career success was held in 2008. This is a collaborative effort between the major stakeholders in the state, the University of Hawai‘i Systemwide Office and State of Hawai‘i Department of Education. Each of these perspectives will be examined in further detail.

The goals of the continuing State of Hawai‘i Mathematics Summit series are to: (1) improve the mathematics pipeline leading to career and college ready mathematics, (2) improve alignment of courses so that students transition smoothly between institutions and courses, and (3) prepare more qualified and effective mathematics teachers/instructors.

The State of Hawai‘i Department of Education is doing its part to raise mathematics preparation of all graduates by revising mathematics benchmarks, quality education, and graduation requirements. Specifically, this includes an increase of 3 to 4 credits of mathematics

for the graduating class of 2013. The goal is to have 50% of students achieve the DOE recognition diploma in 2013, and 80% by 2018. Students will need to achieve, at the minimum, the level of algebra II. Incentives for completing the DOE recognition diploma include scholarships, college admission with honors, placement into college level mathematics courses, and carpentry or dry wall apprenticeship program application test waivers. State Superintendent Patricia Hamamoto has clearly expressed, “We need to figure out how to reach our students that are different learners. Drill and kill doesn’t work anymore. Our future teachers have to be solid in content and pedagogy. We spend too much money in the DOE on re-teaching our mathematics teachers” (Hamamoto, P., Personal Conversation, January 19, 2009).

In the past, many students taking algebra 2 went on to major in STEM fields. However, now, the students in algebra 2 classrooms comprise of a more diverse group of students who have differing learning styles. We need teachers to teach to the strengths of the students, and not rely habitually on methods that may have worked for the advanced students. Thus, given various career paths, how do we help students transition into University of Hawai‘i colleges and universities? For students entering the remedial and development courses, how does policy help them transition into college-level courses?

We need to improve the mathematics pipeline leading to career and college ready mathematics so that we not only increase the number of students earning degrees, but more specifically increase the number of STEM degrees. The University of Hawai‘i systemwide strategic goal for degrees and certificates of achievement earned is an increase of 3-6% per year and an increase in the number of University of Hawai‘i STEM degrees by 3% per year. Not enough students performing well in University of Hawai‘i pipeline to higher level mathematics courses. Only 1/5 of entering University of Hawai‘i community college students successfully

completed a remedial/developmental mathematics course in Fall 2006. 5,538 students began in the entering cohort, and only 1,149 successfully completed at least one remedial/development course in their first academic year (UH IRO, 2012). There is a huge leak in the pipeline.

University of Hawai‘i production falls significantly short in terms of annual teacher vacancies, and this has been a major area of focus in recent years. In AY2007-2008, there were 418 qualified mathematics teachers. However, in 2007-2015 the state is projected to need 1,432 qualified mathematics teachers, and last year the total University of Hawai‘i systemwide production of mathematics education majors was 28. Only 47.8% of secondary mathematics courses are being taught by “highly qualified” teachers, as deemed by the Hawai‘i State Teachers Standard Board (UH IRO, 2012). According to University of Hawai‘i Vice President of Academic Planning and Policy Linda Johnsrud, the mental ability to do the process that comes with doing mathematics is paramount. “We don’t need more human calculators; we need people who can think” (Johnsrud, L., Personal Conversation, October 10, 2011).

The major stakeholders in the State Hawai‘i are committed to taking action to improve the pipeline leading to “career and college ready” mathematics, improve the alignment of courses so that students transition smoothly between institutions and courses, and prepare more qualified and effective mathematics teachers. Given the policy framework outlined, ethnomathematics has been implemented as a tool to bridge policy with practice in order to accomplish these goals.

Overview of Ethnomathematics

The term *ethno* describes “ingredients that make up the identity of a group: language, codes, values, beliefs, community, class, food and dress, habits, and physical traits” (D’Ambrosio, 2001, p. 308). *Mathematics* expresses a “broad view of mathematics which includes arithmetic, classifying, ordering, inferring, and modeling” (D’Ambrosio, 2001, p. 308).

An understanding of these terms allows teachers to expand their mathematics perceptions and more effectively instruct their students in a growing school climate of diversity.

Teachers and the public in general do not commonly say that mathematics and identity are connected. When teachers do acknowledge a link, they often engage their students in multicultural activities merely out of curiosity. Such activities usually refer to a culture's past and to cultures that are removed from that of the students in the class. An important component of mathematics education today should be to reaffirm the individuality and identity of students. As students experience mathematics in this manner, they not only learn to value mathematics but also develop a greater respect for those who are different from themselves.

Just as literacy has come to mean much more than reading and writing, mathematics must also be thought of as more than counting, calculating, sorting, and comparing. Today's children are living in a civilization that functions by mathematically based technology and unprecedented means of communication. A very clear picture of future employment opportunities is given by Robert Reich (1992) in *The Work of Nations*. This picture includes the need for a technologically capable work force whose members participate in the global economy and are able to create solutions to problems that currently do not exist, with technologies that have not yet been invented. A goal of mathematics education should be to build upon students' abilities to successfully use a diverse array of knowledge to solve problems and communicate their thinking as they gain an awareness of the capabilities and limitations of an interconnected global community (Ascher, 1987, 1991; Thomas, 1985, 1987).

Ethnomathematics encourages us to witness and attempt to understand how mathematics continues to be adapted and used by people around the world. Students should be encouraged to construct personal mathematical understandings and be able to explain their work. When all

students' invention, experience, and application of mathematics are realized and respected, they are given equal opportunity for access and achievement (Harvard University Achievement Gap Initiative, 2008; Kyselka, 1987; UCLA Center X, 2008).

The mathematical ideas of the peoples of the Pacific region have often been overlooked, particularly in science, technology, engineering, and mathematics. Every cultural group develops its own ways and styles of explaining, understanding, and coping with their environment. In recent years, there has been recognition that among indigenous peoples there were other non-Western forms of knowledge, responses to survival, and wisdom. There is tremendous value in knowledge systems that back different societal structures (Harvard University Achievement Gap Initiative, 2008; Stroup, 1985; UCLA Center X, 2008).

Particularly in Pacific communities, it is central to understand how space and time are integrated. This is critical when we study peoples whose behavior is intimately related to the sea and to navigation as highlighted in the opening 'ōlelo no'eau (proverb). Pacific communities relied heavily on canoeing and navigation to survive in the past, produced a technology that still resonates today, and exemplify the importance and processes of spatial and linear conceptualizations (Babayan, Finney, Kilonsky, & Thompson, 1987; Chauvin, 2000; Finney, 1979, 1986).

Ethnomathematics was forged in the experiences, reflections, and hopes for a better quality of life. In the next section, I will show how ethnomathematics may be used as a tool to connect policy and practice in U.S. higher educational institutions in the following three main areas: (1) equity and quality education, (2) building successful partnerships and practices, and (3) mentoring in diverse populations. Before delving into these, an overview of the University of Hawai'i – West O'ahu (UHWO) is provided.

University of Hawai‘i – West O‘ahu

Within the University of Hawai‘i system there are 10 campuses, including three universities and seven community colleges. Headcount enrollment at the University of Hawai‘i 10 campuses measured 53,526 in Fall 2011, and the University of Hawai‘i - West O‘ahu (UHWO) campus posted the largest enrollment increase in percentage terms of any campus in Fall 2011 at 21.3%. This is a product of UHWO moving into a new phase of growth in Fall 2007, with the transition from a two-year upper division campus to a four-year, comprehensive university with an emphasis on the liberal arts, serving professional, career-related, and applied fields (UHWO Mission Statement, 2011). This is an especially critical period to support and retain traditionally underrepresented populations, particularly in the science, technology, engineering, and mathematics disciplines.

To provide some general information, UHWO is the only four-year baccalaureate degree granting degree institution on the west side of the island of O‘ahu. The new campus in the city of Kapolei is scheduled to open its doors in Fall 2012. UHWO is accredited by the Accrediting Commission for Senior Colleges and Universities of the Western Association of Schools and Colleges, and offers more than 20 bachelor and certificate programs. UHWO provides distance learning programs for residents on six of the eight inhabited islands, Hawai‘i, Kaua‘i, Lāna‘i, Maui, O‘ahu, and Moloka‘i.

The average age of students is 31 years old, and the ethnic breakdown is as follows: Asian/Pacific Islander 11%, Caucasian 15%, Filipino 15%, Chinese 3%, Japanese 13%, Native Hawaiian 25%, Mixed 13%, and Other 5%. UHWO has the highest percentages of Native Hawaiians and Filipinos at any four year university, public or private, in the State of Hawai‘i. Of the academic achievement statistics, the most striking differences occur in Native Hawaiian and

Filipino groups. The ethnically diverse student body at UHWO will continue to grow as highlighted by projections that the population will increase by 216.1% in seven years from 866 students in 2006 to 1,872 students in 2013 (UH IRO, 2012). This provides an ideal setting to nurture, develop, and celebrate cultural heritage and identity in mathematics.

Equity and Quality Education

First, in terms of equity and quality education, the most effective programs address issues of support and retention with a systematic, multi-faceted approach involving a variety of teaching/learning strategies, integrated mentoring programs, and course-based learning assistance (Astin & Oseguera, 2005; Bok, 2006; Hurtado, 2001). In Spring 2008, UHWO opened its first Mathematics Center with the support of a National Science Foundation grant. The Mathematics Center has a three-fold purpose of providing academic mentoring, personalized tutoring, and research experiences, all of which are critical to achieve the goal of increased student success in college, particularly for traditionally underrepresented students.

The National Science Foundation funding has allowed UHWO to effectively address and work toward accomplishing the strategic plan in terms of immediate, intermediate, and long term mathematics goals. Tutoring has serviced the immediate needs of assisting students enrolled in mathematics courses. The UHWO Mathematics Center plays an instrumental role on campus since all UHWO students are required to take one college level mathematics course to fulfill graduation requirements. The intermediate and long term goals are to provide a bachelor's degree in middle and secondary mathematics education, along with relevant experiences, to address one of the State of Hawai'i's paramount challenges. The UHWO Mathematics Center is the central hub for mathematics.

The mission of the UHWO Mathematics Center is to uniquely: celebrate cultural heritage and diversity, honor common values, foster a global community of students and educators, encourage global sustainability, and catalyze positive change. There are four main principles that reflect the culture and traditions of the communities we serve. These principles inform and direct educational efforts, and focus on promoting a positive learning environment:

1. Navigation: Vision, exploration, education.
2. Honoring Elders: Tradition, heritage, kupuna, family, our first people.
3. Environment: Our sacred earth.
4. Island Living: Our Pacific ‘ohana and our special multiethnic community.

According to ethnomathematics scholar Marcia Ascher, “Mathematical ideas involve number, logic, or spatial configuration, and in particular, the combination or organization of these into cultural systems or structures” (1998, p. 185). We have learned through ethnomathematics how deeply cultural values can impact teaching, learning, and curriculum; and how mathematics education can then affect political and social dynamics and policies in the schooling process.

Within the areas of navigation, honoring elders, environment, and island living, the central values are:

- Mālama: To care for
- Aloha: To love
- ‘Imi ‘Ike: To seek knowledge
- Lokomaika‘i: To share with each other
- Na‘au Pono: To nurture a deep sense of justice

- Olakino Maika‘i: To live healthy

Specifically, through mālama, each student is cared for individually and collectively as part of a larger organization. In aloha, love is the foundation to capitalize on unique contributions in the process of ‘imi ‘ike or seeking knowledge. Lokomaika‘i is necessary to share with and learn from each other in a mutual process of continual growth. In doing so, a bond is created between past, present, and future generations by nurturing a deep sense of justice, equity, and fairness in na‘au pono. Finally, the planet earth, like Hawai‘i, is an island which is cared for and sustained through olakino maika‘i. These are Hawaiian values, but they are also universal values. Their impact crosses state, national, and international boundaries and most importantly, instills in students a sense of global responsibility.

The UHWO Mathematics Center fosters an environment where diverse students learn to think critically, receive tutoring and mentoring support, hone skills, and prepare for jobs to ensure the future mathematics development of the State of Hawai‘i and beyond.

Building Successful Partnerships and Best Practices

Second, ethnomathematics has provided a framework for building successful partnerships and practices. Collaboration has taken place between campus administration, the Pacific Islands Mathematical Association of Two-Year Colleges, Hawai‘i Council of Teachers of Mathematics, Polynesian Voyaging Society, University of Hawai‘i Systemwide Office and State of Hawai‘i Department of Education. Each understands the importance of quality learning, teaching, and personal development.

For example, over the past five years, UHWO has been involved with the Polynesian Voyaging Society’s Hōkūle‘a. The Hōkūle‘a, “star of gladness,” is a double-hulled Hawaiian voyaging canoe that is an integral part of the UHWO Mathematics Center and connects students

to cultural and historical traditions. The Hōkūle‘a is internationally renowned for the role it has played in rekindling the Pacific Island tradition of non-instrument way-finding techniques that include celestial navigation to locations such as Tahiti, Rapa Nui, Rarotonga, Marquesas Islands, Samoa, Micronesia, Japan, and the U.S. mainland, and is preparing for a voyage around the world in 2013 of which the author will be participating in. Thousands of children around the world have connected to the Hōkūle‘a in the last 35 years. She is a powerful vehicle to explore real-world applications of mathematics in the Hawaiian and global communities, and represents resourcefulness, inventiveness, wisdom grounded in the past, and hope for the future (Finney, Kilsonky, Somsen, & Stroup, 1986; Honolulu Star-Bulletin, December 26, 2007; Jonsson, 1988; Pacific Business News, December 20, 2007).

According to Hōkūle‘a navigator Nainoa Thompson, “Our ancestors sailed across a vast ocean, one third of the earth’s surface, and to accomplish this great feat they needed mathematical vision and tools to see islands over the horizon, the ability to plan intentional voyages of discovery, the discipline to train physically and mentally, the courage to take risks, and a deep sense of aloha to bind the crew together during the voyage. The values worked in the past and they will work today” (Thompson, N., Personal Conversation, October 29, 2011).

Ethnomathematics scholar Ascher continues, “Mathematics has no generally agreed-upon definition; it means to some degree what was included in their formal Western models of schooling” (1998, p. 2-3). Some attempts to define mathematics emphasize its objects of study and others its methods; some definitions are extremely narrow and others exceptionally vague and broad. Concerns about what mathematics is are generally in the domain of philosophers and the historians who write its history. Many societies, including Native Hawaiian, did not have a formal system of writing until Western contact. As a result, the category “mathematics” is

Western and not necessarily found in traditional cultures. Such is the case in Hawai‘i, where people for centuries performed complex calculations of trigonometric angles, wind speed, and geometrical star houses, yet there was no word for “mathematician” or “scientist” (Babayan, Finney, Kilonsky, & Thompson, 1987; Best & Hongi, 1906; Lewis, 1977).

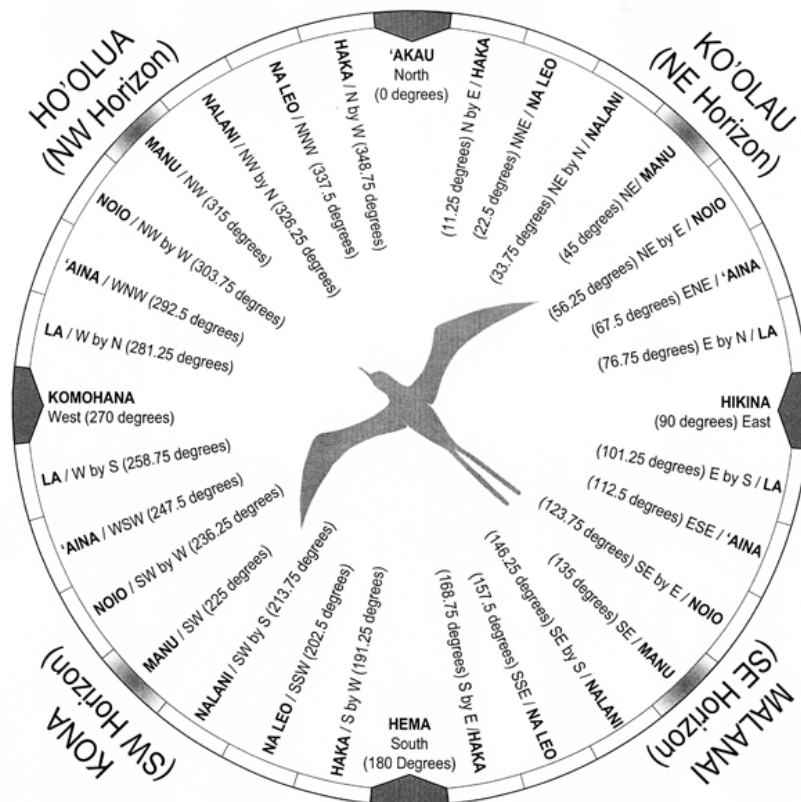
In order to inculcate the value of their culture, UHWO students and future mathematics teachers are actively involved with voyaging and lesson planning. While sanding surfaces and varnishing rails of the Hōkūle‘a, students learned about the connectivity of mathematics and ancient pathways based on celestial navigation. The Hawaiian star compass is the foundational element in navigation. The canoe is oriented to the rising and setting points of stars, and the distant horizon is divided into a compass comprising 32 equidistant directional points of 11.25° . Each point is the midpoint of a directional house, or hale, hence the 32 houses of 11.25° each divide and organize the 360° circular horizon into equally placed hale that the stars reside in (see figure below).

The star compass is like a mirror. Excluding the names of the four main cardinal points, the seven remaining names reflect each other in all four of the divisional quadrants. A star rising in one house travels a path that parallels the celestial equator - never crossing it and set in the same named house on the opposite side of the compass. For example, a star rising in the house of ‘Āina Ko‘olau sets in the house of ‘Āina Ho‘olua. Ocean swells, however, always travel in a direction that moves from one horizon passing through the canoe and exiting in a direction that is directly opposite. For example, a swell that travels from the compass house ‘Āina Ko‘olau moves in a direction that passes through the canoe and exits the horizon in the compass house of ‘Āina Kona.

Knowing the rising and setting points of the many different celestial bodies (sun, moon, stars, planets) combined with knowledge of swell patterns and its placement within the star compass helps the navigator orient the canoe on long journeys. Understanding the relationship between the 32 different houses of the star compass and the canoe is the fundamental first step in non-instrument, celestial navigation.

Upon learning about the mathematical relationships, one student commented:

I didn't realize how much math had to be factored into going on a voyage...the amount of supplies, the dimensions of each canoe, location, and distance and travel time. It was interesting to learn about the historical aspects of the voyage. I want to learn math so I can learn more about the great feats of my ancestors (Bello, M., Personal Conversation, October 27, 2010).



Through working together on real-world mathematics applications in addition to traditional class assignments, the student experience is enhanced through a culturally-sensitive mathematics curriculum in geometry, algebra, statistics, precalculus, and calculus. For example, vectors are discovered through sailing and navigating voyaging canoes first-hand; the Hawaiian Star Compass is used as a guide to study the trigonometric unit circle and apply half-angle and double angle formulas; geometry is investigated by maintaining and caring for Hawaiian fishponds; algebraic functions are studied while playing traditional Hawaiian Makahiki games (season to honor the Hawaiian god Lono) such as throwing spears at banana stalks and rolling stones between various configurations of pegs on the ground.

While it is very important to learn about textbook mathematics, it is equally critical to understand that there were great mathematicians that emerged from Hawai‘i and the Pacific Islands, including the students’ ancestors.

Mentoring in Diverse Populations

Third, in a widely cited report, the National Center for Public Policy and Higher Education (2004) indicates that only 18 out of 100 students complete any type of postsecondary education within six years of graduating from high school. The outcomes of the Hawai‘i pipeline are below the national average with only 13 completing a postsecondary degree (UH IRO, 2012). The same study shows that mentoring and building relationships is one of the most effective ways to prevent attrition. Based on ethnomathematics, mentoring activities are a built-in component of developing mathematics at UHWO through cultural and historical-based field studies, and projects between future mathematics teachers in local high schools.

For example, the Polynesian Voyaging Society has invited UHWO prospective as well as current high school teachers to participate in designing educational curriculum for the Hōkūle‘a.

With a legacy of ocean exploration as its foundation, the Polynesian Voyaging Society and UHWO reaffirm our commitment to undertake voyages of discovery, respect and learn from our heritage and culture, and strengthen learning which integrates voyaging experiences through mentoring experiences. There is a firm commitment to nurturing communities that value learning and share knowledge in order to foster living well on islands. Through mentoring and voyaging, we have come to celebrate cultural heritage and diversity, while honoring common values.

Among the products of the mentoring program between UHWO prospective high school teachers, current high school teachers, and the Polynesian Voyaging Society is an array of educational curriculum for future voyages included in the Starter Pack for Teachers. For example, these include development of a Hōkūle‘a education website, satellite phone calls, crewmember visits, canoe tours, curriculum resources, and teacher sails. The Starter Pack for Teachers was created to increase involvement with the voyage both on the canoe and in the classroom. There are multiple educational opportunities for teachers, students, and schools throughout the world. Through the Hōkūle‘a Education Program weblog online forums, a student space and teacher space, students and teachers from around the world can meet and get to know each other, and communicate and exchange ideas on important themes connected to the voyage such as environmental stewardship, cultural heritage, and sustainability related to mathematics.

Whenever possible, students and teachers have the opportunity, via satellite phone, to speak with and ask questions directly to crew members on the canoes as they travel across the Pacific. Upon arriving in each port, Hōkūle‘a crew members visit with teachers, students, and schools for canoe tours and educational lectures. UHWO prospective teachers and current high

school teachers also sail together on the Hōkūle‘a to experience navigation first-hand. These travels have gone to extraordinary places in the Hawaiian Islands and have enabled a committed network of teachers to help Polynesian Voyaging Society design culturally-sensitive mathematics curriculum.

We seek to form a global community of students and educators to create a more sustainable world and cultivate positive change. In the process, this provides prospective UHWO mathematics teachers with the opportunity to make this dream a reality and accomplishes State of Hawai‘i mathematics goals. The Hōkūle‘a Education Program website serves as a communication platform to bring students and teachers worldwide together to share their ideas, knowledge, and mathematics perspectives that help foster a more integrated and sustainable world (http://pvs.kcc.hawaii.edu/hoonaauao/intro_hoonaauao.html). An additional resource is the Hōkūle‘a Worldwide Voyage website (<http://www.hokuleawwv.org/>).

Hawai‘i, our special island home, is a place where the land and sea are cared for, and people and communities are healthy and safe. As another example of mentoring in diverse populations, each semester UHWO mathematics students visit the Hawai‘i Institute of Marine Biology, a world-renowned research institute situated on Coconut Island in Kāne‘ohe Bay. This ideal location is just 15 miles from the main campus of the University of Hawai‘i and downtown Honolulu, and allows students to learn more about intersections of culture, environmental awareness, conservation, tropical marine science, and mathematics in their Hawaiian backyard.

Coconut Island is surrounded by 64 acres of coral reef, designated by the State of Hawai‘i as the Hawai‘i Marine Laboratory Refuge. The island itself covers approximately 29 acres, with six acres enclosed in lagoons that are used for keeping organisms in captivity for study. Coconut Island provides research facilities for its faculty and students, as well as visitors, who come from

all over the world. Through field studies to Coconut Island, students form mentoring relationships with researchers that allow them to consider STEM related fields for careers, future graduate work and studies, and lifelong learning.

This is evidenced by the comments of a student in a reflection following the field study to Coconut Island:

What made this trip interesting is the fact that we were taught how to use math formulas that we had learned in class in a real world situation, such as determining the population growth of a certain species through functions or mapping the reefs surrounding Coconut Island through linear equations. Overall this was probably one of the most practical ways for us as a class to see how math can be used in a real life situation, and personally it definitely beats a classroom setting any day of the week. However, what topped this experience off is the fact that we were able to interact with the ocean's sea creatures and learn about its previous inhabitants from our mentors. All in all, this was definitely a once in a lifetime opportunity that I'm glad I didn't miss (Pasion, M., Personal Communication, April 13, 2011).

Examples of student work may be found in research and practicum-based textbooks that have been distributed throughout the state, "Ethnomathematics Curriculum Textbook: Precalculus, Trigonometry, and Analytic Geometry" (2011) and "Ethnomathematics Curriculum Textbook: Algebra, Geometry, and Number Foundations" (2010). The textbooks serve to engage current and prospective mathematics teachers and mathematicians by continuing dialogue on critical themes in mathematics, supplementing mathematics curriculum, and enriching teacher training materials.

According to the National Council of Teachers of Mathematics' Position Statement on Equity in Mathematics Education, a culture of equity depends on the joint efforts of all participants in the community of students, educators, families, and policymakers, among which includes, "The school community acknowledges and embraces all experiences, beliefs, and ways of knowing mathematics...High expectations, culturally relevant practices, attitudes that are free

of bias, and unprejudiced beliefs expand and maximize the potential for learning...All students have access to and engage in challenging, rigorous, and meaningful mathematical experiences” (January 2008). Such practices empower all students to build a relationship with mathematics that is positive and grounded in their own cultural roots and history. All members of the classroom group must accept the responsibility to engage with and support one another throughout the learning experience, which is a critical component of mentoring and fulfilling State of Hawai‘i mathematics goals.

Further Discussion

The successes have been tremendous, and we continue to meet and overcome challenges. In the past couple of years, we have worked to develop a bachelor of arts degree in mathematics education to work towards fulfilling the teacher shortage in the State of Hawai‘i at the middle and secondary levels (Harvard University Achievement Gap Initiative, 2008; Kyselka, 1987; UCLA Center X, 2008). Through implementing the best practices strategies, we have seen the proportion of underrepresented students double in mathematics courses, particularly for Native Hawaiian and Filipino populations. The overall passing rate has increased and almost doubled from 42.8% to 80.6%, far above the average passing rate for the University of Hawai‘i system (UH IRO, 2012). Furthermore, more students are taking mathematics courses, necessitating additional courses in precalculus elementary functions and analytic geometry.

Challenges have included securing additional funding for development of the UHWO Mathematics Center with the increasing student body population. However, based on the overwhelmingly positive statistics, we have built partnerships to facilitate this growth, including local and statewide organizations. The National Council of Teachers of Mathematics states,

“Mathematics performance and learning of groups that have traditionally been underrepresented

in mathematics fields can be improved by interventions that address social, affective, and motivational factors. Recent research documents that social and intellectual support from peers and teachers is associated with higher mathematics performance for all students, and that such support is especially important for many African American and Hispanic students” (2008, p. 6).

There has never been a more important time to cultivate sustainable conditions that advance student success in college. Building relationships based on students’ backgrounds is one of the most effective ways to increase student retention and success. This study began with a macroperspective analysis based on collaborative research with major stakeholders and policymakers in the State of Hawai‘i. There are tremendous benefits of solidifying values, overcoming challenges, and working together with the University of Hawai‘i Systemwide Office and State of Hawai‘i Department of Education. An overview of policy provided a framework for understanding mathematics at the national, state, and local levels, including the importance of quality learning and teaching in personal development.

Ethnomathematics has proven to be an effective bridge between policies introduced at the macroperspective level and hands-on practices and learning experiences in the communities we are serving. As examples of best practices, this study covered three: (1) equitable and quality education, (2) successful partnerships and practices, and (3) mentoring in diverse populations. Based on principles of ethnomathematics, researchers at Harvard University, UCLA, and the University of Hawai‘i explored examples of work at the UHWO Mathematics Center funded by the National Science Foundation; the Hōkūle‘a, a double-hulled Hawaiian voyaging canoe that is an integral part of the center and connects students to cultural and historical traditions; and the Hawai‘i Institute of Marine Biology’s Coconut Island’s fostering environment of student

Achievement Gap Initiative, 2008; Honolulu Star-Bulletin, December 26, 2007; Pacific Business News, December 20, 2007; UCLA Center X, 2008).

It is hoped that students, educators, and communities will engage in communication that will allow us to collectively examine how universal values bind us together. The planet earth, like Hawai'i, is also an island which must be cared for and sustained instilling in each of us a sense of global responsibility. In the words of Polynesian Voyaging Society President and navigator Nainoa Thompson, "It is not about the canoe. The canoe is a piece of it. It is those beliefs and principles that you are willing to sail for. It is about the minds and hearts of children. I hope your voyages are a catalyst to change how to help children embrace the future, and that is why we are sailing around the world" (Thompson, N., Personal Conversation, October 29, 2011). Whether the journey is at the local, state, or national level, may we work together to be catalysts of positive change.

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